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ABSTRACT

This paper reports the results of a 2-year study investigating the types of experiences and support necessary for in-service teachers to effectively integrate Geographic Information Systems (GIS) in their teaching/learning environments. The complex nature of GIS software prompted the authors to ask whether GIS can be a useful tool in the classroom. In an effort to answer this question, workshops were conducted, assessed, and revised in an iterative process. Assessment measures included classroom observations, interviews, participation in Web-based discussions, and lesson plan analyses. Results include documentation and rationale for the evolution from an intensive multi-day workshop with follow-up classroom support to a three-part series of workshops distributed over a 6-month period with classroom support available. Qualitative analyses include excerpts from classroom observations, interviews, and lesson plans which contrast the level and type of use by teachers who participated in the in-services. Many of the 15 participants in the first workshop did not successfully integrate GIS into their classrooms settings. The large majority of participants in the last workshop were able to plan and implement lessons incorporating GIS in meaningful contexts. GIS is a tool that is being used extensively by researchers, scientists, and planners. Until recently it was not feasible for educators to use this spatial data resource because the cost of the software was prohibitive and the size of the data files was too large to load on the personal computers used in most school settings. Demand from public and private sectors, coupled with spiraling innovations in technology, have resulted in the recent introduction of software which can be used to manipulate spatial data on personal computers. Software companies such as Environmental Systems Research Institute, Inc. (ESRI) have produced software bundles for school systems at affordable educational prices. Educators who have had the opportunity to explore these resources are excited about the potential of these spatial data resources to enhance the achievement and conceptual understanding of students in content areas including geography, science, mathematics, art, and technology. Students can investigate real-world problems to understand concepts and patterns about such topics as climate, human usage patterns, and the earth as a system. These same patterns can serve as inspiration for art projects, and the software tools can allow

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multiple perspectives. Students can also take on the role of planners by querying the spatial data to help manage crop production, range management, county, and city planning. The purpose of this study is to develop effective professional development workshops in the use of GIS. This includes the support and information necessary for interested Wyoming teachers to use these resources in their classrooms to increase and enhance student achievement in areas of art, science, mathematics, geography, and technology. (Author/YDS)

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Initiating the Use of GIS Technology in Wyoming Public Schools Through In-Service Workshops

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Abstract

This paper reports the results of a two year study investigating the types of experiences and support necessary for in-service teachers to effectively integrate Geographic Information Systems (GIS) in their teaching/learning environments. The complex nature of GIS software prompted the authors to ask whether GIS can be a useful tool in the classroom. In an effort to answer this question, workshops were conducted, assessed and revised in an iterative process. Assessment measures included classroom observations, interviews, participation in web-based discussions and lesson plan analyses. Results include documentation and rationale for the evolution from an intensive multi-day workshop with follow-up classroom support to a three-part series of workshops distributed over a six-month period with classroom support available. Qualitative analyses include excerpts from classroom observations, interviews and lesson plans which contrast the level and type of use by teachers who participated in the in-services. Many of the fifteen participants in the first workshop did not successfully integrate GIS into their classroom settings. The large majority of participants in the last workshop were able to plan and implement lessons incorporating GIS in meaningful contexts.

Geographic Information Systems (GIS) is a tool that is being used extensively by researchers, scientists and planners. Until recently it was not feasible for educators to use this spatial data resource because the cost of the software was prohibitive and the size of the data files was too large to load on the personal computers used in most school settings. Demand from public and private sectors coupled with spiraling innovations in technology have resulted in the recent introduction of software which can be used to manipulate spatial data on personal computers. Software companies such as Environmental Systems Research Institute, Inc. (ESRI) have produced software bundles for school systems at affordable educational prices.

Educators who have had the opportunity to explore these resources are excited about the potential of these spatial data resources to enhance the achievement and conceptual understanding of students in content areas including geography, science, mathematics, art and technology. Students can investigate real-world problems to understand concepts and patterns about such topics as climate, human usage patterns, and the earth as a system. These same patterns can serve as inspiration for art projects and the software tools can allow multiple perspectives. Students can also take on the role of planners by querying the spatial data to help manage crop production, range management, county and city planning.

The purpose of this study was to develop effective professional development through workshops in the use of GIS. This included the support and information necessary for interested Wyoming teachers to use these resources in their classrooms to increase and enhance student achievement in areas of art, science, mathematics, geography, and technology.

Implementation of Effective Professional Development

The fact that the tools are now available to allow schools to use these powerful spatial data resources does not mean that this will happen automatically. For starters, the majority of educators are not aware of these resources. The education literature is full of examples where teachers were expected to incorporate new technologies and/or content into their teaching. Teachers that participate in one-time, intense workshops to learn about new technologies or content often lose enthusiasm, skills, and understanding gained in the workshops after a period of time. Without sustained, quality staff development long-term change in teacher practices is not likely to occur (Fullan, 1991; Joyce & Showers, 1988, Little, 1993; Loucks-Horsley, Hewson, Love & Stiles, 1998).

Professional development can take many forms, including workshops, institutes, courses, and seminars. Each of these strategies has unique characteristics and serves a specific purpose for continuing learning and growth possibilities for educators. When producing professional development the designer must consider these qualities to best match the purpose of the learning opportunity, the content, and the needs of the participants.

These strategies, however, do not have to be used independent of the others. Depending on the learning goals of the professional development, Loucks-Horsley, et al. (1998) recommended combining one or more of these strategies, such as an intense workshop followed by a seminar. Loucks-Horsley, et al. also stated that, "the best workshops, seminars, and institutes are designed to include a variety of modes through which learners can process information," (p. 88, 91) such as small group discussions, engaging in problem solving, and exploring questions.

Even though each of the described strategies has unique qualities, they also share key elements and implementation requirements. For more in-depth descriptions of these, the reader is encouraged to read Designing Professional Development for Teachers of Science and Mathematics by Loucks-Horsley, et al. (1998). The aforementioned text describes five implementation requirements for workshops, institutes, courses and seminars. These include: 1) expert knowledge through a leader or facilitator; 2) time away from the workplace, with arrangements for substitutes or stipends, to free teachers from their regular duties; 3) a curriculum or syllabus to inform the participants about the content; 4) Access to resources and materials, i.e. classroom materials, texts, tutorials, and software; and 5) incentives such as stipends or graduate credit. These requirements apply to all workshops, etc., including those aimed at overcoming barriers to using technology in the classroom such as insufficient time and training, lack of vision, and unclear ideas about the role of technology (O'Neill, 1995).

GIS in the Classroom

The EdGIS Conference final report (1995) supported the need for effective professional development in using GIS in the classroom. It stated, "For GIS to have a broader impact on education, progress needs to be made in several key areas of implementation: development of exemplary curriculum materialsÖ teacher training, and dealing with issues of equity of access" (p. 19). This call for quality teacher training is supported further by a survey of educators using GIS in their classrooms. Audet & Paris (1997) found that 77% of respondents strongly agreed that teacher training is necessary before introducing GIS in the classroom. In addition, 75% of those surveyed agreed or strongly agreed that teaching with GIS requires new teaching methods.

The need for learning new teaching methods along with the need for learning how to use GIS points to the need for the development of effective teacher in-service in these areas. The purpose of this study was to develop effective professional development experiences for teachers to learn how to use GIS and implement it into their classrooms. To accomplish this goal, workshops were conducted, assessed and revised in an iterative process. Assessment measures included classroom observations, interviews, participation in web-based discussions and lesson plan analyses.

Description of the Research

The efforts to provide Wyoming teachers with content background and skills to use GIS in the classroom began in 1995 through the development of the Earth System Science Internet Project (ESSIP). The primary goal of this project was to form a collaborative partnership between scientists and science educators at the

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University of Wyoming and K-12 teachers throughout Wyoming. The project focused on creating authentic learning experiences through the use of remotely sensed data, spatial data accessible over the Internet, and participating in collaborative lessons using the Internet across multiple sites.

The team of university faculty and public educators developed eight activity modules for use in the project, one of which involved using GIS to conduct four spatial investigations. For instance, in one lesson the students explored patterns in and between land cover, hydrology, geology, topography, and species habitats. Before the teachers could pilot these lessons, however, they had to learn how to use GIS.

In 1996, fifteen 6^{th}-12^{th} grade geography and science teachers from five school districts participated in a week-long workshop at the University of Wyoming to learn the basics of ArcView GIS (ESRI, Inc.) and test the GIS module lessons. As part of the module development process, the teachers were asked to test each of the lessons in their classes and provide feedback to the project directors during the 1996-97 academic year. To assist the teachers in this process, continual support from GIS technology specialists on the ESSIP staff was provided in the form of personal visits, e-mail, and telephone conversations.

Classroom observations and teacher interviews provided the bulk of the data from the first iteration. Each of the teachers was visited during the school year and interviewed about the strengths and weaknesses of the lessons, obstacles to implementation, and suggestions for improving various aspects of the project. The teachers were then brought back together in the summer of 1997 to discuss these same issues.

The remainder of 1997 marked an expansion of the GIS component of ESSIP. Increased efforts were made to provide other 6^{th} -12^{th} grade teachers with the opportunity to learn how to use GIS and incorporate it into the curriculum. For this second iteration, conducted over the 1997-98 academic year, several changes were made to the content and format of the workshop based on the feedback from the first workshop participants. As with the first iteration of the workshop, the participants in the second iteration received support through classroom visits, e-mail, and phone calls. A two-day follow-up workshop was convened a year later in February 1999 to allow participants to share their successes and failures in implementing GIS, review the basic functions of ArcView, and learn more advanced features of the software.

Once again, classroom observations and teacher interviews were employed to gather data about the efficacy of the in-service. Additionally, analysis of the web-based discussions and participant-developed lesson plans implemented in the second iteration provided further data sources.

Results

Observations from classrooms during the first iteration provided information about the introduction of GIS to 6^{th}-12^{th} students which was then transferred to introducing the software to teachers participating in the second iteration. Students were observed using GIS as an exploratory tool, so the second iteration was planned to provide more opportunities to explore data. In addition, student groups of two appeared to work best where resources were limited, but a 1:1 student-to-computer ratio was ideal, so greater emphasis was placed on each participant having access to a computer in the second iteration.

Along with observing the students, the teachers were tracked and interviewed regarding their use of the modules and general participation in the project. Five teachers expressed hardware obstacles as the primary reason for not fully participating. Seven others described unrelated commitments as the main obstacle in participation. Only three teachers felt satisfied in their implementation of the GIS lessons. Each of the teachers had volunteered and made a commitment to participate, but a stronger incentive was needed to encourage full participation. As a result, the second iteration was offered for graduate credit from the University of Wyoming. After the second iteration was complete, the researchers noted that all but two of the workshop participants that finished the extended in-service had taken the course for credit.

Direct feedback from the participants after the first iteration proved most helpful in redesigning the second workshop format. The participants' suggestions which were directly implemented in the second iteration included:

- creating a non-computer-based introduction to GIS concepts such as using transparencies to demonstrate overlaying themes and querying;
- allowing students to create their own data layers to increase motivation and emphasize the local focus of GIS;
- spending more time discussing databases, queries, and the syntax of querying;
- addressing the need for complying with state and national standards;
- learning how to customize the lesson plans;
- involving more teachers from other districts; and
- integrating other content areas.

The participants also provided feedback about difficulties in accessing computers with sufficient memory or other hardware requirements, arousing support from administrators and colleagues, and simply remembering how to use the software due to the lag-time between the workshop held during the summer of 1996 and implementation of the lessons several months later during the 1996-97 academic year.

This feedback was used to make several modifications for the second workshop. First, the format of the workshops was modified from an intense week-long workshop to a seven day, three-part workshop extended over a six month period. This was to give the participants opportunities to test and refine their skills at home and in the classroom between sessions. The intermediate session would then provide reinforcement, remediation, and continued development in the midst of implementation efforts.

Second, teachers were sought from the areas of mathematics, science, art and geography to provide a greater emphasis on interdisciplinary connections of using GIS. The resulting content composition of the teachers in the second workshop consisted of science (7), geography (4), elementary (4), math (3), art (2), and history (1). Third, the content of the workshop was expanded to include remote sensing concepts and the use of Global Positioning System (GPS). Teaching students to use GPS would allow them to generate their own data sets. Fourth, all the participants were expected to complete homework assignments during the breaks between workshop sessions. These assignments included identifying state and district curriculum outcomes and standards that could be addressed by using GIS/GPS, developing, teaching and evaluating lesson plans for their students, and posting their ideas, assignments and comments on the ESSIP web-based discussion site.

Thirty-six teachers initially registered for the second workshop, but only twenty-one completed the extended seven-day series, nineteen of which took the course for credit. Each of these nineteen teachers identified relevant district and state outcomes and standards as well as posted ideas on the discussion site. Twenty teachers developed lesson plans, with fourteen being able to implement and evaluate them. Three of the teachers who were unable to implement their plans cited lack of access to capable hardware and three stated that they did not have sufficient time to test their plans.

A follow-up workshop was conducted in February 1999 for the participants in the second iteration. Thirteen teachers stated at that time that they were able to continue implementing GIS and GPS after the completion of the course. Two others were still set back by hardware and time obstacles but stated their intention to forge ahead in their efforts. The remaining six had discontinued using GIS in their classrooms.

Along with teacher participation and workshop development, this study also examined the level and type of use by the teachers who participated. As might be expected by the spread of grade levels and content areas, the complexity of the lesson plans varied. Generally, the elementary and middle school teachers as well as the art teachers used GIS to conduct simple visual investigations without resorting to the Boolean or other intensive querying capabilities of the software. For instance, a sixth grade teacher designed a lesson using GIS to introduce her students to the five themes of geography by looking at such things as the characteristics and features of a place. An art teacher asked her students to use GIS to investigate land forms and land marks then create their own land mark stamps. The students then used these stamps along with principles of design and printmaking skills to create new maps of the areas under investigation.

The junior high and high school science, geography and mathematics teachers tended to use more of the software's functionality. Three teacher's work demonstrating a more complex level of use are presented here.

Patti Kimble, an 8th grade science teacher prepared and tested a lesson about which physical features of an area need to be considered before drilling an oil well. She wrote:

> The purpose is to prepare students for our Oil Rig Simulation by getting them to think about what problems may occur because of natural and human features, and what things could be affected by drilling a well. Students will eventually be asked to write Environmental Impact Statements for Drilling, and by looking at actual features around actual wells, we can start discussing the potential problems they may need to address.

Bryan Aivazian, a junior high earth science teacher, designed a plan in which the students would investigate seismic activity and the associated seismic risks in Yellowstone National Park by posing such questions and scenarios as:

> "Does the number and location of seismic events remain relatively constant each year in the park? Ö - Do significant seismic events occur near areas of sustained human use, so that some assessment of the likely risk of a seismic event occurring can be conducted? The quake events would have to be examined in relationship to the physical environment of the park (mountains, valleys, rivers, geysers) as well as the human features there (roads, campgrounds, visitor stations, etc.). Not only could the students point out the relative likelihood of seismic events in areas of current use in the park, but they could also provide some information on potential high risk areas that should be avoided."

Finally, Paul Anderson, a high school mathematics teacher, used GIS to print maps on graph paper for students to calculate area using Trapezoidal Rule and Simpson's Rule. After testing the lesson Mr. Anderson wrote,

> "One thing that I forgot about was to have them select an appropriate map projection which displayed with equal areas. This was the cause of some errors in their calculations. I had a thought, though, that this would be a good comparison lesson, to have different students map the same regions using different projections. Then they could see how much the projection matters in calculating the correct area."

When given the opportunity, the participants of the second workshop were able to develop useful, appropriate lessons involving GIS. Comments from these participants indicated that they were excited about using GIS to teach content they were already responsible for teaching and saw greater potential for integrating this technology into their teaching practice.

Discussion

Designing effective professional development is a complex task. The purpose of the learning opportunity, the content, and the needs of the participants must be matched with an appropriate strategy or combination of strategies for promoting learning and change. Then the professional development must be implemented in such a way as to provide expertise, support learning, and encourage participation through incentives.

When introducing new technologies, additional factors must be considered, such as providing technical and moral support as well as a sufficient time period to enable the learners to become comfortable with the technology. The learners must also see the possibilities for applying and integrating the new technology into existing curricular structures. As Audet & Paris (1997) stated, there is a distinction between "knowing how to operate a GIS and knowing how and when to apply GIS to solve problems" (p. 300). Appropriate professional development would allow teachers to learn how to manipulate GIS and how to apply it meaningfully in the classroom setting.

Both iterations of the workshop in this study shared characteristics and elements such as workshop instruction methods and hands-on activities, technical and moral support structures, and follow-up sessions. Some of the teachers in both workshops experienced technical obstacles, lack of administrative support, and

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sufficient time to fully implement lesson plans involving GIS.

The second iteration of the GIS workshop, however, draws closer to meeting the effective professional development models described by Loucks-Horsley, et al. (1998) than the first iteration. It appears to have been more effective in promoting lasting change in teaching practice in terms of ability to use GIS and implement it into the classroom. The extended time frame of the workshops, stronger incentives, interdisciplinary connections, outside assignments to design and test lessons, and on-going communication using the web-based discussion site were all significant changes from the first iteration. One or a combination of these changes may be the primary factor for increasing the effectiveness of the second workshop. Further interviews of the participants need to be conducted to identify specific aspects of the workshop that led to changes in their practice.

The iterative process is ongoing in the GIS workshops being conducted by the Earth System Science Internet Project. A third iteration is currently in progress aimed at providing GIS in-service on a regional basis. Interdisciplinary teams of teachers from each of the participating schools were recruited to attend the workshops and collaboratively design and develop lessons and projects with GIS as the connecting strands. Plans are also under development to conduct similar workshops in four other regions in Wyoming by the end of 2000. Each will provide opportunities to continue the research into and refinement of best professional development strategies for introducing and implementing GIS into the pre-college curriculum.

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